USDA NRCS

United States
Department of
Agriculture

Natural
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Conservation
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Agricultural Waste Management Systems - Level 2

Review Activities Workbook

UNITED STATES DEPARTMENT OF AGRICULTURE

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Review Activities Workbook

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Part 1
Review Activities

Module 2
Agricultural Waste Characteristics

Review Activities

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2. Compute the animal units for 10,000 laying hens with an average weight of five pounds per hen.

3. Compute the pounds of total nitrogen in a waste storage pond having 20 acre-feet storage with a concentration of 200 mg/L.

4. Using AWMFH, Table 4-5, calculate the daily production of nitrogen for a dairy consisting of . . .

500 1400 pound lactating cows.
100 1400 pound dry cows.
50 750 pound heifers.

5. Using AWMFH, Table 4-2, convert 900 pounds of nitrogen to an equivalent pounds of nitrate (NO_3).

6. Using AWMFH, Table 4-2, convert 500 pounds of phosphorus to an equivalent pounds of phosphate (P_2O_5).

Module 3
Geology and Ground Water Quality Considerations

Review Activities

1. What are the two performance objectives for an AWMS in terms of the site's geology? Explain each one.

a. ____

____

____

b. ____

____

____

2. What two aspects of an AWMS have the potential to contaminate ground water?

a. ____

____

____

b. ____

____

____

3. What are the two basic concerns related to accommodation of an AWMS structural component?

a. ____

____

____

b. ____

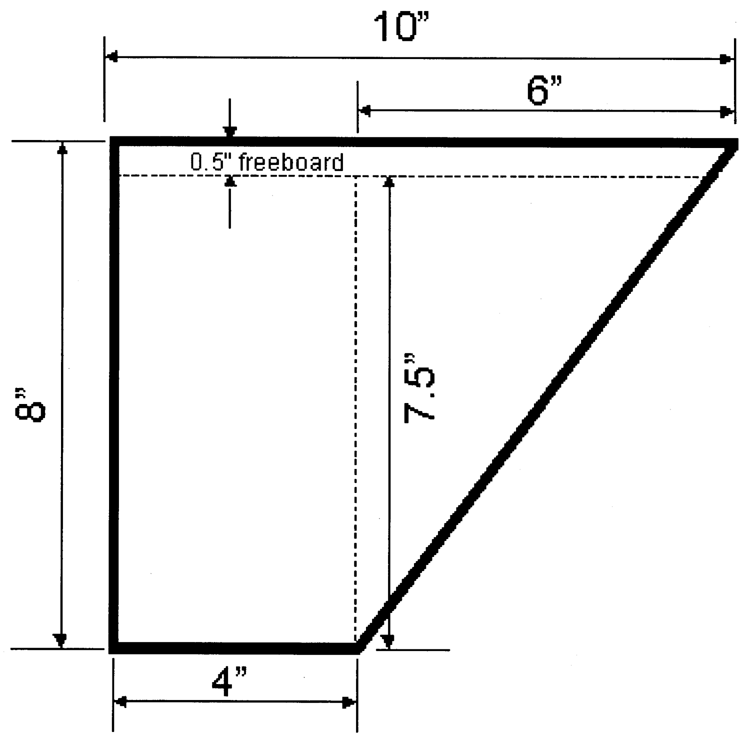
____

____

Module 6a
Production Function Component Design

Review Activity

Find the roof area that could be served by the gutter shown below and six-inch diameter downspouts with a 10-year, five-minute precipitation of 0.5 inches. Assume the gutter gradient is 1/16 inch per foot.



Module 6c
Storage Function Component Design

Review Activities

1. List what is included in the storage requirement for a waste storage facility.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

e. ______________________________

____

2. Determine the waste storage requirement for a covered waste storage tank given the following . . .

200, 1400 pound Holstein milkers
50, 1000 pound Holstein heifers
120-day storage period
85 gallons wastewater per lactating cow per day

Module 6d
Treatment Function Component Design

Review Activities

1. List the ten treatment function components.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

2. Determine the minimum treatment volume (MTV) for an anaerobic lagoon for a feeder hog swine operation given the following facts . . .

Location	Ames, Iowa
Number of animals	1200
Average weight	150 pounds

3. For the facts given for a swine operation in activity 2, determine surface area for an aerobic lagoon.

4. Determine the volume for the primary bin(s) size for a poultry mortality composter with the following facts . . .

A broiler operation	20,000 chickens per cycle
Mortality Rate	5 percent
Number of days to reach market weight	42 days
Market weight	4.2 pounds
Volume factor	2.5

5. Determine the required cross sectional area (A) for a settling basin with a design flow (Q) of 2 cubic feet per second.

Module 6f
Geotechnical, Design and Construction Guidelines

Review Activities

1. Given the following laboratory information on percent of fines (percent finer than the #200 sieve) and plasticity index (PI), determine in which permeability group the sample belongs according to Appendix 10D.

Sample	Percent fines	PI	Group
1	58	32	
2	15	40	
3	42	16	
4	18	4	
5	22	18	
6	49	5	

2. Calculate the required thickness (d) for a soil liner for a waste storage pond given the following . . .

Depth of liquid in pond (H)	15 feet
Soil permeability (k)	0.0023 ft/day
Allowable specific discharge (v)	0.028 ft/day

3. Calculate the required maximum coefficient of permeability (k) for a soil liner for a waste storage pond given the following . . .

Depth of liquid in pond (H)	12 feet
Thickness of liner (d)	1.5 feet
Allowable specific discharge (v)	0.0028 ft/day

4. Calculate a new factor of safety (FS) for the sample problem in the lesson (Module 6f, Geotechnical, Design and Construction Guidelines, page 73) by considering some site subsurface drainage to lower the seasonal high water table so z = 2 feet.

Module 7
Waste Utilization (Nutrient Management)

Review Activities

1. A decisionmaker has a big gun equipped with a nozzle capable of an application rate of 0.8 in/hr. He has three fields available for waste application -- field #1 has sandy loam soil; field #2, loam soil; and field #3, silt loam soil. The decisionmaker would like to apply 1.25 inches of waste to all three fields with his current big gun and nozzle.

a. Assuming there are no water holding capacity problems or nutrient loading problems, would it be acceptable to apply waste on all three fields at the 0.8 inch per hour application rate? If not, for which field or fields would this be unacceptable? Use AWMFH, Table 11-2.

____

____

____

b. For the sake of simplicity of operation, the decisionmaker would like to have the same application amount on all three fields. What would be a recommended application amount to allow the decisionmaker to use his current equipment on all fields? Use AWMFH, Table 11-2.

____

____

____

c. If the waste contains 3% solids, and the decisionmaker wanted an application amount of not less than 1.25 inches, the decisionmaker would need to modify his equipment. What would be the maximum application rate you could recommend for field #3? Use AWMFH, Tables 11-2 and 11-3.

____

____

____

d. If the waste contains 2% solids and the rating for the big gun is increased to 1.8 in/hr, what would be an acceptable application amount for field #1? Use the reduction coefficient from AWMFH, Table 11-3 to adjust the application amount in AWMFH, Table 11-2.

2. A livestock operation has a liquid pump designed to deliver no more than 3% solids. The manure pond contains a slurry of 10% solids.

a. Using AWMFH, Figure 11-2, calculate how many gallons of water are needed per cubic foot of slurry in order for the pump to perform within its operational parameters?

b. State three reasons why the percent solids in the waste material affect the design of an irrigation system for applying wastes.

(1)

(2)

(3)

c. Dilution may solve the physical problems listed in activity 2a above. What might be another reason to consider dilution in an irrigation system?

3. Calculate the amount of phosphorus needed to replace the harvested portion of a 4-ton per acre tall fescue hay crop? Use AWMFH, Table 6-6.

4. Calculate the expected daily waste production "as excreted" on a weight basis from a dairy herd consisting of 500 lactating Holsteins weighing an average of 1400 pounds and fifty Holstein heifers averaging 900 pounds each. Use AWMFH, Table 4-5.

5. List three methods for estimating the nutrient content of manure. Provide advantages and disadvantages for each of the three methods.

a. ______________________________

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____

____

b. ______________________________

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____

____

c. ______________________________

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6. Calculate the pounds of Mn, Cu and Zn, if the manure analysis in one ton of fresh poultry litter is . . .

Mn = 320 ppm Cu = 640 ppm Zn = 530 ppm

____

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____

7. Suppose 5 tons of poultry litter is applied per acre to a 40-acre cornfield. Local analysis revealed that the manure consisted of 1% Ammonical nitrogen (NH_4-N) and 3.5% total N and that N availability during the first year was 60%.

a. How much total nitrogen is being applied per acre?

____

____

____

b. How much N is available for this crop year?

____

____

____

____

____

____

8. Explain the impact animal waste utilization can have on the following . . .

a. Soil ____

____

____

b. Water ____

____

____

c. Air ____

____

____

d. Plants ____

____

____

e. Animals ____

____

____

f. Humans ____

____

____

9. List the components of a waste utilization plan.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

10. The operation and maintenance component of the Waste Utilization Plan should obviously include the operation and maintenance recommendations for equipment and structures, such as paying attention to the level of the waste in a waste storage pond and agitating material before irrigation. What are some of the operation and maintenance components of waste utilization?

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____

____

11. Name two other planning criteria that may be used in developing the waste utilization plan.

a. ____

____

____

b. ____

____

____

Module 9
Operation, Maintenance and Safety

Review Activities

1. What is the "owner's manual" for an agricultural waste management system called?

____

2. What are two important elements that must be present while planning an AWMS to assure that the decisionmaker will accept ownership of an AWMS?

a. ____

____

b. ____

____

3. In the context of an AWMS, how is "operation" defined?

____

____

____

4. In the context of an AWMS, how is "maintenance" defined?

____

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____

5. In the context of an AWMS, how is "safety" defined?

____

____

____

6. What are the three major hazards of an AWMS?

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

7. What are the recommended basic outline elements of an AWMS plan?

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

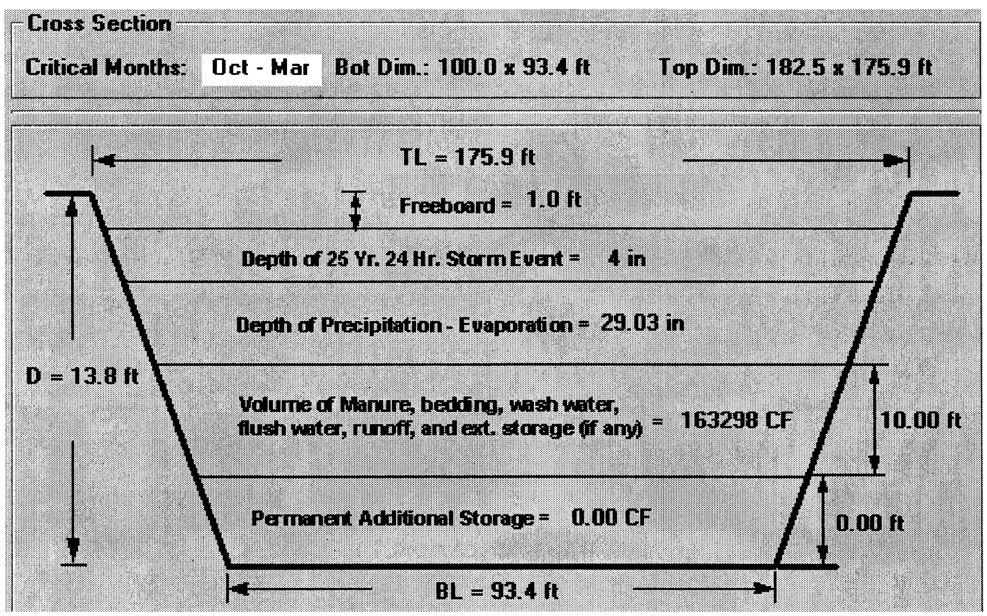
g. ______________________________

h. ______________________________

8. Case Study.

NRCS is developing an agricultural waste management system for Paul Green, the decisionmaker for an all Holstein dairy with 300 milking cows, 100 dry cows, and 100 heifers. Among other components, the AWMS includes a waste storage pond. Your assignment is to develop the operation and maintenance, and safety action items related to the waste storage pond for inclusion in the AWMS plan.

The waste storage pond was designed using the national NRCS Animal Waste Management computer program, and is dated 7/18/00. The design is attached with a planned cross section. The cross section shows elevations and volumes associated with the waste storage pond. The waste storage pond has been designed to have a storage period of 6 months. The nutrient management plan calls for applying the effluent from the waste storage pond using an irrigation system to several fields of orchardgrass between May 1 and August 30.



a. What are some of the operational activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan? (Hint: Review AWMFH Appendix 13C, Operation, Maintenance, and Safety Inspection Guidelines)

____

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____

____

b. What are some of the maintenance activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan? (Hint: Review AWMFH Appendix 13C, Operation, Maintenance, and Safety Inspection Guidelines.)

____

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c. What are some specific safety activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan? (Hint: Review AWMFH, Figure 13-6.)

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____

d. For the waste storage pond above, at what level is the pond to be considered full and drawdown should begin? (Hint: Review AWMFH Figure 10-14 and Figure 10-15.)

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Module 11
Sampling and Monitoring

Review Activities

1. List and describe seven purposes for sampling and monitoring.

a. ______________________________

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b. ______________________________

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c. ______________________________

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d. ______________________________

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e. ______________________________

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f. ______________________________

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g. ______________________________

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2. Describe monitoring wells and soil lysimeters. What are they used for? How are samples collected from each?

a. Monitoring wells

b. Soil lysimeters

3. What are the primary nutrients as discussed in this module? Describe some of their forms.

Part 2
Review Answers

Module 2
Agricultural Waste Characteristics

Review Answers

1. Compute the animal units for 800 Holstein cows with an average weight of 1400 pounds per cow.

Solution:

$$AU = \frac{800 \times 1400 \text{ lbs}}{1000 \text{ lbs/AU}} = 1120$$

2. Compute the animal units for 10,000 laying hens with an average weight of five pounds per hen.

Solution:

$$AU = \frac{10{,}000 \times 5 \text{ lbs}}{1000 \text{ lbs/AU}} = 50$$

3. Compute the pounds of total nitrogen in a waste storage pond having 20 acre-feet storage with a concentration of 200 mg/L.

Solution:

$$\text{Total wt.} = \frac{20 \text{ ac-ft} \times 43560 \text{ ft}^2 \times 62.4 \text{ lbs}}{1 \text{ ac} \times 1 \text{ ft}^3}$$

$$\text{Total wt.} = 54{,}362{,}880 \text{ lbs}$$

$$\frac{200}{1{,}000{,}000} = \frac{x}{54{,}362{,}880}$$

$$1{,}000{,}000x = 54{,}362{,}880 \times 200$$

$$x = 10{,}873 \text{ pounds of nitrogen}$$

4. Using AWMFH, Table 4-5, calculate the daily production of nitrogen for a dairy consisting of . . .

500 1400 pound lactating cows
100 1400 pound dry cows
50 750 pound heifers

Solution:

Calculate the 1000 lb AU for each class of dairy animal.

Lactating Cows

$$AU = \frac{500 \times 1400 \text{ lbs}}{1000 \text{ lbs/AU}} = 700$$

Dry Cows

$$AU = \frac{100 \times 1400 \text{ lbs}}{1000 \text{ lbs/AU}} = 140$$

Heifers

$$AU = \frac{50 \times 750 \text{ lbs}}{1000 \text{ lbs/AU}} = 37.5$$

Using AWMFH, Table 4-5, select the daily nitrogen production for each class of dairy animal.

Lactating Cows	0.45 lbs/day/1000 lb AU
Dry Cows	0.36 lbs/day/1000 lb AU
Heifers	0.31 lbs/day/1000 lb AU

Calculate the daily production of nitrogen for each class of dairy animal.

Lactating Cows	=	700 AU x 0.45 lbs/day/1000 lb AU	=	315 lbs/day
Dry Cows	=	140 AU x 0.36 lbs/day/1000 lb AU	=	50 lbs/day
Heifers	=	37.5 AU x 0.31 lbs/day/1000 lb AU	=	12 lbs/day

Calculate the total daily production of nitrogen.

Total Nitrogen = 315 lbs/day + 50 lbs/day + 12 lbs/day = 377 lbs/day

5. Using AWMFH, Table 4-2, convert 900 pounds of nitrogen to an equivalent pounds of nitrate (NO_3).

<u>Solution</u>:

900 pounds of N x 4.425 = 3,982 pounds of NO_3

6. Using AWMFH, Table 4-2, convert 500 pounds of phosphorus to an equivalent pounds of phosphate (P_2O_5).

<u>Solution</u>:

500 pounds of P x 2.288 = 1,144 pounds of P_2O_5

Module 3
Geology and Ground Water Quality Considerations

Review Answers

1. What are the two performance objectives for an AWMS in terms of the site's geology? Explain each one.

a. Environmental - Minimizing leaching of contaminants into the ground water.

b. Structural - The site's capability to provide a suitable foundation and of being excavated, if necessary, for AWMS components.

2. What two aspects of an AWMS have the potential to contaminate ground water?

a. Land applied wastes.

b. Earthen waste-storage and treatment impoundments.

3. What are the two basic concerns related to accommodation of an AWMS structural component?

a. Characteristics of the material on which the structure is to be located.

b. Depth to the water table.

Module 6a
Production Function Component Design

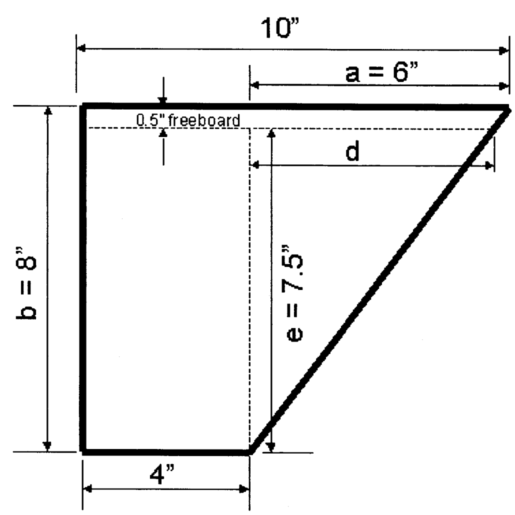
Review Answer

Find the roof area that could be served by the gutter shown below and six-inch diameter downspouts with a 10-year, five-minute precipitation of 0.5 inches. Assume the gutter gradient is 1/16 inch per foot.

Solution:

Step 1 – Compute the capacity of the gutter.

Compute the cross sectional area (A_g) of the gutter.



$a / b = d / e$

$6 \text{ in}/8 \text{ in} = d/7.5 \text{ in}$

$8 \text{ in} \times d = 6 \text{ in} \times 7.5 \text{ in}$

$d = 45.0 \text{ in}^2 / 8 \text{ in}$

$d = 5.62 \text{ in}$

$A_g = (4 \text{ in} \times 7.5 \text{ in}) + (0.5 \times 5.62 \text{ in} \times 7.5 \text{ in})$

$= 51.1 \text{ in}^2$

Compute the wetted perimeter (WP) of the gutter.

$WP = 4 \text{ in} + 7.5 \text{ in} + ((5.62 \text{ in})^2 + (7.5 \text{ in})^2)^{0.5}$

$= 4 \text{ in} + 7.5 \text{ in} + (31.58 \text{ in}^2 + 56.25 \text{ in}^2)^{0.5}$

$= 20.9 \text{ in}$

Compute the hydraulic radius (r) of the gutter.

$r = A_g / WP = 51.1 \text{ in}^2 / 20.9 \text{ in} = 2.44 \text{ in}$

Compute the capacity of the gutter (q_g).

q_g $= 0.01184 \times A_g \times r^{0.67}$

$= 0.01184 \times 51.1 \text{ in}^2 \times (2.44 \text{ in})^{0.67}$

$=$ 1.10 cu ft/sec

Note: The constant, 0.01184, evaluates $1.486/n \times s^{0.5}$ in Manning's Equation when n = 0.012 and s = 1/16 inch per foot. The constant also converts the inch units for Ag and r to feet, so the resulting units from the equation are in cubic feet per second.

Step 2 – Compute the capacity of the downspout.

Compute the cross sectional area (A_d)o f a 6 inch diameter downspout.

A_d $=$ pi x (diameter/2)^2

$= 3.1416 \times (6 \text{ in}/2)^2$

$=$ 28.27 sq in

Compute the capacity (q_d) of a 6 inch orifice with a H = 7.5 inches.

q_d $= 0.010457 \times A_d \times H^{0.5}$

$= 0.010457 \times 28.27 \text{ in}^2 \times (7.5 \text{ in})^{0.5}$

$=$ 0.81 cu ft/sec (cfs)

Note: In orifice equation, $Q = CA\,(2gH)^{0.5}$, the constant C = 0.65 is recommended for a circular downspout application when A is in units of square feet and H is in units of feet. For convenience the above equation for qd C has been changed to 0.010457 that accounts for the $(2g)^{0.5}$ and allows units for A to be in square inches and H to be in inches.

Step 3 – Determine if the system is controlled by the gutter capacity or by the downspout capacity and make adjustments to the number of downspouts if desired.

q_g $= 1.10$ cfs $> q_d = 0.81$ cfs Therefore, the downspout capacity controls.

N_d $= q_g / q_d = 1.10$ cfs /0.81cfs $= 1.3$

Use 2 downspouts to take full advantage of gutter capacity.

Step 4 – Determine the roof area (A_r) that the gutter and downspout can serve.

$q \quad = 1.10$ cfs (the lesser of q_g or q_d)

$A_r \quad = q \times 3600/P$

$= 1.10 \text{ cfs} \times 3600/0.5 \text{ in}$

$= 7920 \text{ ft}^2$

Module 6c
Storage Function Component Design

Review Answers

1. List what is included in the storage requirement for a waste storage facility.

a. Manure, wastewater and other wastes accumulated during the storage period.

b. Normal precipitation less evaporation on the surface area of the storage facility during the storage period.

c. Normal runoff from the storage facility's drainage area during the storage period.

d. Residual solids after liquids have been removed.

e. Additional storage as may be required for management goals or regulatory requirements.

2. Determine the waste storage requirement for a covered waste storage tank given the following . . .

200, 1400 pound Holstein milkers
50, 1000 pound Holstein heifers
120-day storage period
85 gallons wastewater per lactating cow per day

Solution:

Compute the equivalent 1000 pound animal units for each animal type.

AU = (N x M) / 1000
where N = Number of animals
W = Average animal weight

Lactating cows
AU = (200 animals x 1400 lb/animal) / 1000 lb animal unit = 280

Heifers
AU = (50 animals x 1000 lb/animal) / 1000 lb animal unit = 50

Compute the volume of excreted manure.

VMD = AU x DVM x D
where AU = Number of I 000 pound animal units
DVM = Daily volume of manure production for animal unit
D = Storage period (days)

From AWMFH, Table 4-5, DVM = 1.3 ft^3/day/AU for both livestock classes

Lactating cows
VMD = 280 AU x 1.3 ft^3/day/AU x 120 days = 43,680 ft^3

Heifers
VMD = 50 AU x 1. 3 ft^3/day/AU x 120 days = 7,800 ft^3

Compute total manure for herd.

TVM = 43,680 ft^3 + 7,800 ft^3 = 51,480 ft^3

<u>Compute the volume of wastewater for the storage period</u>.

Determine the daily wastewater volume (WWD) for lactating cows.

WWD = (WW / 7.48) x number of cows
where WW = Daily wastewater (gallons/day) per animal type
7.48 = Number of gallons in a cubic foot

WWD = (280 cows x 85 gal/day/ww) / 7.48gal / ft^3) / = 3,182 ft^3 / day

Determine wastewater volume for the storage period.

TWW = WWD x D
where D = Storage period (days)

TWW = 3,182 ft^3/day x 120 days = 381,820 ft^3

<u>Compute required volume for the tank</u>.

WSV = TVM + TWW = 51,480 ft^3 + 381,820 ft^3 = 433,300 ft^3

Since the tank is covered, no addition or deduction for precipitation less evaporation or the precipitation for the 25-year, 24-hour storm is included in the volume. Freeboard of 0.5 feet and 0.5 allowance for solids that may not be removed during emptying is added to the depth requirement for the tank.

Module 6d
Treatment Function Component Design

Review Answers

1. List the treatment function components.

a. Anaerobic lagoons.

b. Aerobic lagoons.

c. Mechanically aerated lagoons.

d. Drying/dewatering facilities.

e. Composting facilities.

f. Mechanical separators.

g. Settling basins.

h. Dilution facilities.

i. Vegetative filters.

j. Constructed wetlands.

2. Determine the minimum treatment volume (MTV) for an anaerobic lagoon for a feeder hog swine operation given the following facts . . .

Location	Ames, Iowa
Number of animals	1200
Average weight	150 pounds

<u>Solution</u>:

<u>Compute the equivalent animal units (AU)</u>.

AU = (W x N) / 1000 = (150 lb/animal x 1200 animals) / 1000 lb/AU = 180

<u>Determine daily volatile solids (VS) production per AU</u>.

From AWMFH, Table 4-11, for growers weighing between 40 and 220 pounds, select VS = 5.40 lb/day/AU.

<u>Compute daily volatile solids (TVS) production</u>.

TVS = VS x AU = 5.4 lb/day/AU x 180

= 972 lb VS/day

<u>Compute minimum treatment volume (MTV)</u>.

From AWMFH, Figure 10-22, select VSLR = 4.0 lb VS/1000 ft^3/day.

MTV = TVS / VSLR

= (972 lb VS/day) / (4.0 lb VS/1000 ft^3/day)

= (972 x 1000 ft^3) / 4.0

= 243,000 ft^3

3. For the facts given for a swine operation in activity 2, determine surface area (MTA) for an aerobic lagoon.

Solution:

AU = 180 (from previous computation)

BOD_5 = 2.08 lb/AU/day (from AWMFH, Table 4-11)

TBOD = AU x BOD_5

= 180 AU x 2.08 lb/AU/day

= 374.4 lb/day

From AWMFH, Figure 10-25, select BODLR = 30.0 lb BOD_5/ac/day.

MTA = TBOD / BODLR

= 374.4 lb BOD_5/day / 30.0 lb BOD_5/ac./day

= 12.5 acres

4. Determine the volume for the primary bin(s) size for a poultry mortality composter with the following facts . . .

A broiler operation	20,000 chickens per cycle
Mortality Rate	5 percent
Number of days to reach market weight	42 days
Market weight	4.2 pounds
Volume factor	2.5

Solution:

Vol = B x (M / T) x W x (VF / 100)

where Vol = Volume required for each stage (ft^3)
B = Number of animals
M = Percent of normal mortality for the entire life cycle
T = Number of days for animal to reach market weight
W = Market weight (lb)
VF = Volume factor

Vol = 20,000 birds x (5%/42 days) x 4.2 lb/bird x (2.5 /100)

= 250.0 ft^3

5. Determine the required cross sectional area (A) for a settling basin with a design flow (Q) of 2 cubic feet per second.

<u>Solution</u>:

$Q = AV$

Transposed . . .

$A = Q/V$

Knowing that a settling velocity (V) is 1.5 ft/sec or less, then . . .

$A = 2\ ft^3/sec\ /\ 1.5\ ft/sec$

$= 1.33\ ft^2$

Module 6f
Geotechnical, Design and Construction Guidelines

Review Answers

1. Given the following laboratory information on percent of fines (percent finer than the #200 sieve) and plasticity index (PI), determine in which permeability group the sample belongs according to Appendix 10D.

Sample	Percent fines	PI	Group
1	58	32	IV
2	15	40	II
3	42	16	III
4	18	4	I
5	22	18	III
6	49	5	II

2. Calculate the required thickness (d) for a soil liner for a waste storage pond given the following . . .

Depth of liquid in pond (H)	15 feet
Soil permeability (k)	0.0023 ft/day
Allowable specific discharge (ν)	0.028 ft/day

Solution:

$$d = \frac{k \times H}{\nu - k}$$

$$= \frac{0.0023 \text{ ft/day} \times 15 \text{ ft}}{0.028 \text{ ft/day} - 0.0023 \text{ ft/day}}$$

$$= \frac{0.0345 \text{ ft}^2\text{/day}}{0.0257 \text{ ft/day}}$$

$$= 1.3 \text{ ft}$$

3. Calculate the required maximum coefficient of permeability (k) for a soil liner for a waste storage pond given the following . . .

Depth of liquid in pond (H)	12 feet
Thickness of liner (d)	1.5 feet
Allowable specific discharge (ν)	0.0028 ft/day

Solution:

$$k = \frac{\nu \times d}{H + d}$$

$$= \frac{0.0028 \text{ ft/day} \times 1.5 \text{ ft}}{12 \text{ ft} + 1.5 \text{ ft}}$$

$$= 0.00031 \text{ ft/day}$$

4. Calculate a new factor of safety (FS) for the sample problem in the lesson (Module 6f, Geotechnical, Design and Construction Guidelines, page 73) by considering some site subsurface drainage to lower the seasonal high water table so z = 2 feet.

Solution:

Given:

$d = 1.5$ feet

Side slopes = 3H:1V and therefore, $\alpha = 18.43$

$\gamma_{water} = 62.4 \text{ lb/ft}^3$

$\gamma_{sat} = 110.0 \text{ lb/ft}^3$

$z = 2$ feet

Then:

$$FS = \frac{\gamma_{sat} \times d \times \cos(\alpha)}{z \times \gamma_{water}}$$

$$= \frac{110.0 \text{ lb/ft}^3 \times 1.5 \text{ ft} \times \cos(18.43)}{2 \text{ ft} \times 62.4 \text{ lb/ft}^3}$$

$$= \frac{156.5}{124.8} = 1.25$$

Conclusion: FS = 1.25 is greater than the acceptable FS = 1.1. Therefore, subsurface drainage would reduce the buoyancy to acceptable limits.

Module 7
Waste Utilization (Nutrient Management)

Review Answers

1. A decisionmaker has a big gun equipped with a nozzle capable of an application rate of 0.8 in/hr. He has three fields available for waste application -- field #1 has sandy loam soil; field #2, loam soil; and field #3, silt loam soil. The decisionmaker would like to apply 1.25 inches of waste to all three fields with his current big gun and nozzle.

a. Assuming there are no water holding capacity problems or nutrient loading problems, would it be acceptable to apply waste on all three fields at the 0.8 inch per hour application rate? If not, for which field or fields would this be unacceptable? Use AWMFH, Table 11-2.

It would be unacceptable on field #3. Table 11-2 shows that for silt loam soil and a 1.25 inch waste application amount, the application rate should not exceed a 0.7 in/hr.

b. For the sake of simplicity of operation, the decisionmaker would like to have the same application amount on all three fields. What would be a recommended application amount to allow the decisionmaker to use his current equipment on all fields? Use AWMFH, Table 11-2.

If the decisionmaker used no more that a 1.0 inch waste application amount and his current irrigation equipment rated at 0.8 in/hr, he would be sure not to exceed the maximum application rate for any of the fields.

Field #1	Sandy loam	1.99 in/hr max application rate
Field #2	Loam	0.98 in/hr max application rate
Field#3	Silt loam	0.82 in/hr max application rate

c. If the waste contains 3% solids, and the decisionmaker wanted an application amount of not less than 1.25 inches, the decisionmaker would need to modify his equipment. What would be the maximum application rate you could recommend for field #3? Use AWMFH, Tables 11-2 and 11-3.

Table 11-3 shows that with 3% solids on a silt loam soil, the application reduction coefficient would be 0.87. Table 11-2 shows a 0.70 in/hr application rate for an application amount of 1.25 inches.

Therefore, 0.87 X .70 in/hr = 0.61 in/hr application rate.

d. If the waste contains 2% solids and the rating for the big gun is increased to 1.8 in/hr, what would be an acceptable application amount for field #1? Use the reduction coefficient from AWMFH, Table 11-3 to adjust the application amount in AWMFH, Table 11-2.

Table 11-3 shows that with 2% solids on a sandy loam soil, the application reduction coefficient would be 0.63.

Select a value from the sandy loam row, say 2.97 in/hr. When 2.97 in/hr is multiplied by the 0.63 reduction coefficient, the new value for a maximum application rate = 1.87 in/hr. The 1.8 in/hr application rate of the sprinkler is less than the 1.87 in/hr maximum; therefore, use a 0.5" application amount or less. This will offset the soil intake reduction induced by the 2% solids.

2. A livestock operation has a liquid pump designed to deliver no more than 3% solids. The manure pond contains a slurry of 10% solids.

a. Using AWMFH, Figure 11-2, calculate how many gallons of water are needed per cubic foot of slurry in order for the pump to perform within its operational parameters?

In Figure 11-2 on the vertical y-axis, locate the desired percent solids resulting from the dilution (3%). From that point, move horizontally until you reach the 10% solids in manure curve. At this point, follow a vertical line down and interpolate the number of gallons needed per cubic foot of original slurry material.

The answer is a minimum of 17 gallons of water is required for every cubic foot of slurry.

b. State three reasons why the percent solids in the waste material affect the design of an irrigation system for applying wastes.

(1) Pump and nozzle equipment must be appropriately selected to the type, size and percent solids contained in the waste.

(2) Additional friction losses may have to be accounted for as the percent solids exceeds 4%.

(3) A reduction in soil intake/infiltration rate may occur if percent solids exceeds 0.5%. Sprinkling rates may have to be adjusted to compensate for this phenomenon.

c. Dilution may solve the physical problems listed in activity 2a above. What might be another reason to consider dilution in an irrigation system?

There may be some chemical problems relating to the soil-water-plant relationship such as oxygen demand in the root zone, leaf burn, pH imbalances and toxic ammonia affects.

3. Calculate the amount of phosphorus needed to replace the harvested portion of a 4-ton per acre tall fescue hay crop? Use AWMFH, Table 6-6.

From Table 6-6, the percent P of the dry harvested tall fescue is 0.20%.

Four tons of tall fescue hay weighs 8000 pounds.

8000 lb/acre tall fescue X 0.0020 P = 16 lb P / acre.

And converting to P_2O_5, 16 lb/acre X 2.3 = 36.8 lb P_2O_5 /acre.

Remember that this represents the amount of P removed from the field by the harvested portion of the crop. It does not represent the amount of P contained in the total plant, including root and stems, nor the quantity of P taken up by the plant. Roots, crowns and stems remain in the field to decompose and become part of the P-cycle.

4. Calculate the expected daily waste production "as excreted" on a <u>weight basis</u> from a dairy herd consisting of 500 lactating Holsteins weighing an average of 1400 pounds and fifty Holstein heifers averaging 900 pounds each. Use AWMFH, Table 4-5.

First, determine the number of 1000 lb animal units (AU) for each animal class.

$$\text{Lactating AU} = \frac{500 \times 1400 \text{ lbs}}{1000 \text{ lbs/AU}} = 700$$

$$\text{Heifers AU} = \frac{50 \times 900 \text{ lbs}}{1000 \text{ lbs/AU}} = 45$$

Using table 4-5, select the daily “as excreted” weight for each animal class.

Lactating cows 80 lbs/day/AU Heifers 85 lbs/day/AU

Calculate total daily “as excreted” weight

Lactating cows	700 AU x 80 lbs/day/AU =	56000 lbs/day
Heifers	45 AU x 85 lbs/day/AU =	<u>3825 lbs/day</u>
		59825 lbs/day

5. List three methods for estimating the nutrient content of manure. Provide advantages and disadvantages for each of the three methods.

a. Use the AWMFH tables in Chapter 4 and apply appropriate losses in the collection, storage and treatment processes found in Chapter 11.

Advantages - Nutrient composition estimates are readily available in Chapter 4; may be only source of information; every field office has a copy of the AWMFH; average is compiled from a large geographic area with diverse operations.

Disadvantages - AWMFH uses average values that may not be indicative of conditions; calculations with ranges of a series of factors can lead to wide variability in results.

b. Use local values, typically called "book values" that are developed by local universities or the Cooperative Extension Service.

Advantages - Values are derived from more local conditions; using book values supports the information and management programs of local universities and State agencies.

Disadvantages - Values vary with different types and weight of livestock, feed rations and collection/storage facilities; values may not exist or may not have been updated in many years.

c. Use actual measurements.

Advantages - Values derived using this method would be most precise; values representative of actual facility.

Disadvantages - Requires that the facility be operational or access to a comparable facility is feasible.

6. Calculate the pounds of Mn, Cu and Zn, if the manure analysis in one ton of fresh poultry litter is . . .

Mn = 320 ppm Cu = 640 ppm Zn = 530 ppm

Set up ratio formula as follows . . .

For Mn

$$\frac{\text{320 parts}}{1{,}000{,}000} = \frac{\text{Mn pounds}}{\text{2000 pounds}}$$

1,000,000 Mn = 320 x 2000
1,000,000 Mn = 640,000

Mn = 0.64 pounds

For Cu

$$\frac{\text{640 parts}}{1{,}000{,}000} = \frac{\text{Cu pounds}}{\text{2000 pounds}}$$

1,000,000 Cu = 640 x 2000
1,000,000 Cu = 1,280,000

Cu = 1.28 pounds

For Zn

$$\frac{\text{530 parts}}{1{,}000{,}000} = \frac{\text{Zn pounds}}{\text{2000 pounds}}$$

1,000,000 Zn = 530 x 2000
1,000,000 Zn = 1,060,000

Zn = 1.06 pounds

7. Suppose 5 tons of poultry litter is applied per acre to a 40-acre cornfield. Local analysis revealed that the manure consisted of 1% Ammonical nitrogen (NH_4-N) and 3.5% total N and that N availability during the first year was 60%.

a. How much total nitrogen is being applied per acre?

10,000 lb manure/acre x 3.5% N = 350 lb N/acre

b. How much N is available for this crop year?

100% of the NH_4-N is available the first crop season.
    10,000 lb manure/acre x 1% NH_4-N = 100 lb N/acre

Organic N is equal to total N minus ammonical N, so subtracting 1.0% ammonical N from 3.5% total N = 2.5% organic N
    10,000 lb manure/acre x 2.5% organic N = 250 lb N/acre.

From local data, 60% of the organic N is available during the year of application.
    60% of the organic N = 0.60 X 250 lb = 150 lb N/acre

Therefore, total N available for this crop year . . .
    100 lb N/acre + 150 lb N/acre = 250 lb N/acre

8. Explain the impact animal waste utilization can have on the following . . .

a. Soil - Manures add organic material to the soil and improve soil structure and biological activity. The nutrients contained in the waste product can be stored in the soil for later use by microorganisms and plants. Heavy metals contained in some waste products are toxic at high concentrations to some microfauna living in the soil. Salts contained in waste products can affect the structure and chemistry of soil. Soil structure can be disturbed by compaction due to waste spreading equipment. Structure, particularly surface sealing, can be affected by the solids contained in liquid manures. Another impact on soils is the fluctuation of the pH that can be caused by waste application.

b. Water - The organic material, nutrients and microorganism present in animal manure can impact surface water quality. Ground water is most often impacted by nutrients and salts that are transformed from the manure and pass through the soil profile into the saturated zone. High levels of nitrate nitrogen and salts can pollute aquifers and make them unfit for drinking or irrigation water. High biological oxygen demand can create a deficit of oxygen in the water column, sometimes to the point of asphyxiating living organisms like fish and snails. Fecal organisms that live in animals can be passed in manure. Some of these fecal organisms cause illness in other animals, including humans, that drink or have contact with contaminated water body.

c. Air - Various “greenhouse gases” (nitrous oxide, carbon dioxide and methane) believed to have an impact on global warming are produced. Ammonia in high concentrations is an irritant of the eyes and throat and causes animal health problems. Although not a greenhouse gas, ammonia travels to the atmosphere where it can combine with water and dust to form nitrous oxides or combine with precipitation to form acid rain. Hydrogen sulfide is a poisonous gas that forms in waste storage tanks. Because it is heavier than normal air, it concentrates inside the tanks and can accumulate to concentrations that are deadly to humans. The most noticed impact on air quality is the production of odor by agricultural waste products. There are more public complaints about odor produced by livestock operations than all the other odor sources combined.

d. Plants - Agricultural waste products supply nutrients to plants. Plants can accumulate heavy metals applied to the soil from agricultural waste products. Salts contained in the waste product can affect germination and growth of many plants. Another impact on plants may be from over-application of nitrogen or potassium. Another imbalance in animal nutrition and health is caused by imbalance applications of nitrogen and potassium to forage grasses. The nutritional imbalance is due to large uptakes of potassium and very small amounts of magnesium in the forage. This is called grass tetany.

e. Animals - Besides the health problems discussed in connection with air and plant impacts, animals are negatively impacted in other ways. Flies proliferate in moist manure. They are a nuisance to livestock and humans and can spread pathogens. Other animal impacts by agricultural waste are caused by fouling of forages by applied manure. Animals reject forage that has been coated by manure. They also reject forage that grows in high concentrated application areas such as urine patches in pasture. Odors and gases cause health and nuisance problems to livestock as well as humans.

f. Humans - Odor and vectors are two by-products of livestock operations that cause the greatest public relations problem to the producer. Recently, the implication of animal waste nutrients being an indirect cause of human health problems through eutrophication of rivers and estuaries has stirred the public concern. Operation of this equipment creates potentially hazardous situations that affect the safety and health of the operator and the local community (noise, slow moving machinery on roads, accident risks).

9. List the components of a waste utilization plan.

a. Total waste from all sources.
b. Nutrient content of the agricultural waste.
c. A nutrient utilization balance.
d. Any restrictions to application.
e. Alternate uses of the waste product.
f. Detailed operation and management plan.
g. Planned conservation practices.

10. The operation and maintenance component of the Waste Utilization Plan should obviously include the operation and maintenance recommendations for equipment and structures, such as paying attention to the level of the waste in a waste storage pond and agitating material before irrigation. What are some of the operation and maintenance components of waste utilization?

a. Soil testing the fields to determine rate of application.

b. Testing the nutrient content of the waste material.

c. Cleaning the irrigation equipment with clean water.

d. Keeping records of application dates and rates.

e. Being aware of environmental sensitive conditions like weather before, during and after application.

f. Planning for safety.

11. Name two other planning criteria that may be used in developing the waste utilization plan.

There is no right or wrong answer to this question. The following is a partial list of items to be considered . . .

a. Distances between application areas and sensitive areas (residential neighborhoods, water bodies, sink holes, highways).

b. Topography or steep slopes.

c. Soil and water conservation practices that need to be implemented in conjunction with waste utilization.

d. High flood risk areas.

e. Distances for pumping and hauling to certain fields.

Module 9
Operation, Maintenance and Safety

Review Answers

1. What is the "owner's manual" for an agricultural waste management system called?

An AWMS Plan.

2. What are two important elements that must be present while planning an AWMS to assure that the decisionmaker will accept ownership of an AWMS?

a. Involvement.
b. Understanding.

3. In the context of an AWMS, how is "operation" defined?

Administrative, management and performance of non-maintenance activities needed to keep the AWMS safe and functioning as planned.

4. In the context of an AWMS, how is "maintenance" defined?

Actions taken to prevent deterioration of system components and to repair damage or replace parts.

5. In the context of an AWMS, how is "safety" defined?

Being safe from undergoing or causing hurt, injury, or loss.

6. What are the three major hazards of an AWMS?

a. Gases.
b. Impoundments.
c. Equipment.

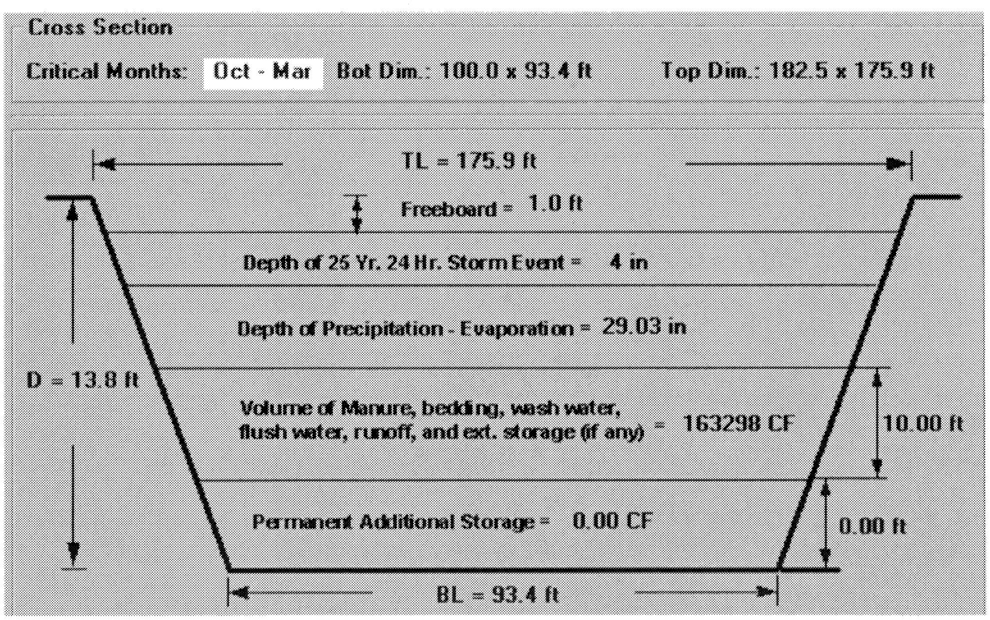
7. What are the recommended basic outline elements of an AWMS plan?

a. Title.
b. Decisionmaker's name, address, and phone number.
c. General statement of purpose of the AWMS.
d. System description.
e. Decisionmaker's responsibilities.
f. Component installation schedule.
g. AWMS Function requirement.
h. Decisionmaker acknowledgment.

8. Case Study.

NRCS is developing an agricultural waste management system for Paul Green, the decisionmaker for an all Holstein dairy with 300 milking cows, 100 dry cows, and 100 heifers. Among other components, the AWMS includes a waste storage pond. Your assignment is to develop the operation and maintenance, and safety action items related to the waste storage pond for inclusion in the AWMS plan.

The waste storage pond was designed using the national NRCS Animal Waste Management computer program, and is dated 7/18/00. The design is attached with a planned cross section. The cross section shows elevations and volumes associated with the waste storage pond. The waste storage pond has been designed to have a storage period of 6 months. The nutrient management plan calls for applying the effluent from the waste storage pond using an irrigation system to several fields of orchardgrass between May 1 and August 30.



a. What are some of the operational activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan? (Hint: Review AWMFH Appendix 13C, Operation, Maintenance, and Safety Inspection Guidelines)

(1) That the filling rate in relation to its filling schedule included in the plan be monitored.

(2) The specific action that should be taken if pond fills prematurely.

(3) Withdrawal schedule between April 1 and September 30 for land application to satisfy the nutrient management plan. Complete drawdown by August 30.

b. What are some of the maintenance activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan? (Hint: Review AWMFH Appendix 13C, Operation, Maintenance, and Safety Inspection Guidelines.)

(1) Routine surveillance of the pond to identify problems, such as leaks, sloughing banks and woody growth, and then taking corrective action if found.
(2) Inspection of the pond when completely emptied. Take corrective action if liner damage is found.
(3) Routine mowing vegetation.

c. What are some specific safety activities related to the above waste storage pond that should be considered for inclusion in the AWMS plan?
(Hint: Review AWMFH, Figure 13-6.)

(1) Maintain fence.
(2) Maintain warning signs.
(3) Maintain access to rescue tools, such as ropes and life rings.

d. For the waste storage pond above, at what level is the pond to be considered full and drawdown should begin? (Hint: Review AWMFH, Figure 10-14 and Figure 10-15.)

At the level below the depth allowance for the 25-year, 24-hour precipitation or
10 feet + 29.03 feet/12 inches/foot = 12.4 feet depth

Module 11
Sampling and Monitoring

Review Answers

1. List and describe seven purposes for sampling and monitoring.

a. Establish a baseline. A baseline establishes the present conditions and can be used as the beginning point to compare changes in resource conditions. One of the problems is that it may require several years of data to establish meaningful baseline conditions and seasonal variations.

b. Determine the fate and transport of pollutants. Monitoring tracks conditions and characteristics (fate) of resource contaminants, such as impacts of manure, as well as tracking the location (transport) of the contaminant through the system; which may be off-site.

c. Define "critical areas." Monitoring can define critical areas within an operation or a watershed with a large contribution to resource problems and can be used to set priorities for resource treatment.

d. Determine conservation practice effectiveness. Sampling and monitoring can be used to determine conservation practice effectiveness, both on-site and off-site. Is the conservation practice performing as designed? For example, is the treatment lagoon reducing the amount of nutrients as planned? Is the conservation practice reducing the pollutant impact on resource (water) quality?

e. Determine allocations. Allocations are two fold and normally used in conjunction with other purposes. First of all, sampling and monitoring can help us determine where to allocate scarce resources. Are there operations that create a resource problem that should have priority for our time and assistance? Secondly, monitoring can be used to determine if a resource can assimilate contaminants.

f. Establish trends. Sampling and monitoring can be used to establish trends, both long term and short term and before and after changes in resource conditions. Trend monitoring is often used to determine overall resource condition such as improving and degrading water quality, but it can also be used to track manure constituents over time.

Collect Data. Sampling and monitoring can be used just to collect data to gain more information. This is useful in determining the constituents of a material, particularly agricultural wastes, and it can be a one-time thing or performed on a recurring basis.

2. Describe monitoring wells and soil lysimeters. What are they used for? How are samples collected from each?

a. Monitoring wells - Monitoring wells vary anywhere from two to six inch diameter pipes installed deep enough to intercept the saturated zone within the study area. The well casing is normally plastic, but can be of any material that does not interfere with the quality of the water to be sampled. Samples from monitoring wells are commonly collected by bailers lowered into a well or by pumping by which water from non-flowing wells is extracted and collected at the surface.

b. Soil lysimeters - Ground pore water in the unsaturated zone is held by tension. As such, it can not be extracted from monitoring wells. Soil lysimeters, also called suction samplers, are the common method for sampling pore water. These samplers consist of a porous ceramic cup mounted on a hollow collection tube. Negative pressure (suction) is applied to the interior of the sampler drawing pore fluid into the ceramic cup for retrieval.

3. What are the primary nutrients as discussed in this module? Describe some of their forms.

a. Nitrogen - Common forms of nitrogen are organic nitrogen measured as TKN or total Kjeldahl nitrogen and ammonium (NH_4). TKN is generally defined as all nitrogen except that in the nitrate/nitrite form. Anaerobic lagoons are a common treatment component in a waste management system. The nitrogen in the effluent from an anaerobic lagoon is most often the organic and ammonium form with very little nitrate or nitrite present. The amount of nitrate in an aerobic system and the relationship of nitrate to ammonium forms are often a performance indicator.

b. Phosphorus - Phosphorus is typically measured as total phosphorus (TP). Other ortho phosphate phosphorus is reported as PO_4 and P_2O_5 in the literature and in sample analyses. In many cases, they are not so much a different measure as they are just a different way of reporting the same result. Readily available phosphorus, ortho-phosphorus and labile phosphorus are other related phosphorus measurements that are used in specific situations. Fertilizer equivalent P is given as phosphate.

c. Potassium - The third primary nutrient is potassium. Potassium is less mobile than nitrogen (less soluble) but much more mobile than phosphorus. Forms of potassium are often identified with the salts. As with phosphorus, potassium is often reported in the combined form -- most often as potash (K_2O), the fertilizer equivalent.